State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

# HAZARD ASSESSMENT OF THE INSECTICIDE METHYL PARATHION TO AQUATIC ORGANISMS IN THE SACRAMENTO RIVER SYSTEM

ENVIRONMENTAL SERVICES DIVISION
Administrative Report 92-1
1992

## PREFACE

The California Department of Fish and Game (CDFG) is responsible for fish and wildlife management programs and is responsible for the protection of fish and wildlife. The CDFG protects fish and wildlife from damage caused by pesticides through consultation as a member on the mandated California Environmental Protection Agency's Department of Pesticide Regulation (DPR) Pesticide Registration and Evaluation Committee and Pesticide Advisory Committee. Through consultation with CDFG, the Regional Water Quality Control Boards also protect fish and wildlife by promulgating and enforcing water quality standards for pesticides and other toxic materials. In recognition of the need for applicable environmental standards for fish and wildlife, DPR contracted with CDFG for the assessment of the effects of pesticides on fish and wildlife and to facilitate the development of water quality criteria which will protect fish and wildlife.

This document is the second in a series of hazard assessments for pesticides used on rice which recommends conditions and studies necessary for the protection of fish and wildlife. A hazard assessment has been prepared for the herbicides molinate and thiobencarb.

# Hazard Assessment of the Insecticide Methyl Parathion to Aquatic Organisms in the Sacramento River System[1,2]

by

Mary Menconi and James M. Harrington

Pesticide Investigations Unit
1701 Nimbus Road, Suite F
Rancho Cordova, California 95670

## SUMMARY

An interim water quality criterion for protection of aquatic organisms from the insecticide methyl parathion was developed for California's Sacramento River system. The discharge of rice pesticides into the Sacramento-San Joaquin Estuary lasts for 45 to 60 days from May through June. Although focused on the effects from rice tailwater in the Sacramento Valley, this hazard assessment may be useful for other crops and environments.

Thirty tests on the acute and chronic effects of methyl parathion to aquatic organisms were reviewed and evaluated. Insufficient data were available to calculate a Final Acute Value (FAV) for methyl parathion according to Environmental Protection Agency (EPA) procedures; data were lacking for insects and mollusks. The most sensitive species tested were the freshwater cladoceran *Daphnia magna* with a mean 48-h $EC_{50}$ value of 0.15 µg/L and the estuarine mysid *Neomysis mercedis* with a mean 96-h $LC_{50}$ value of 0.20 µg/L. Mysids and cladocerans are important food items for many young fish including striped bass *Morone saxatilis* in the Sacramento-San Joaquin Estuary. The calculated interim FAV for methyl parathion was 0.17 µg/L. Similarly, there were insufficient data available to calculate the Final Chronic Value (FCV) from either chronic values or using a Final Acute-to-Chronic Ratio (FACR). An interim FCV was estimated by dividing the interim FAV by an ACR of 2.2, derived from tests with the cladoceran *Ceriodaphnia dubia*, resulting in an interim FCV of 0.08 µg/L. Thus, an interim Water Quality Criterion (WQC) of 0.08 µg/L methyl parathion is proposed.

Methyl parathion exhibits additive acute toxicity with malathion and carbofuran, two insecticides used on rice and found

---

[1] Environmental Services Division Administration Report No. 92-1.

[2] Study funded by California Department of Pesticide Regulation through Interagency Agreement No FG 1005.

concurrently in agricultural drain water. An acceptable level of methyl parathion in the environment may be lower than that proposed here in the presence of the other two insecticides because of cumulative toxicity. Additional study is needed to further characterize additive toxicity among all pesticides used on rice, taking into consideration both lethal and sublethal effects.

Concentrations of methyl parathion were first measured in the agricultural drains in 1980. Maximum concentrations of methyl parathion in drains have declined from 3.7 µg/L in 1981 to 0.30 µg/L in 1991. Concentrations of methyl parathion up to 0.32 µg/L have been detected periodically in the Sacramento River near the city of Sacramento. Methyl parathion concentrations in excess of 0.08 µg/L may have been present in the Sacramento-San Joaquin Estuary in the early 1980s because agricultural drain inputs may have constituted up to 25% of the total Sacramento River flow below the city of Sacramento. However, there is insufficient monitoring data to accurately predict concentrations of methyl parathion in the Estuary during the early 1980s. The proposed interim WQC of 0.08 µg/L for methyl parathion indicates that a hazard to sensitive aquatic invertebrates, especially mysids and cladocerans, was present at times in the agricultural drains and may have been present in the Sacramento River. A toxicological hazard to fish probably was not present in the Sacramento River or the agricultural drains because the acute toxicity values for fish were >1,800 µg/L, while measured levels of methyl parathion have not exceeded 3.7 µg/L.

The hazard assessment procedure is a reiterative process by which new data are evaluated to refine a water quality criterion. Acceptable acute and chronic tests are needed to better define the interim WQC and the effects of methyl parathion on the environment. Acute toxicity tests are required with juvenile stonefly *Pteronarcys californica* nymphs and larval bay mussel *Mytilus californianus* (species resident in the Sacramento River system and the Sacramento-San Joaquin Estuary) to calculate a FAV. Early life-stage chronic toxicity tests are recommended with sheepshead minnow *Cyprinodon variegatus* or rainbow trout *Oncorhynchus mykiss*, and chronic tests are required with the marine mysid *Mysidopsis bahia* or estuarine mysid *N. mercedis* to better define the ACR. A new WQC will be generated when the required data become available. Monitoring of the Sacramento-San Joaquin Estuary should be continued with more sensitive detection limits (<0.05 µg/L) to better assess the hazard posed by methyl parathion to aquatic species.

## TABLE OF CONTENTS

## LIST OF TABLES

## ACKNOWLEDGMENTS

California Department of Fish and Game employees, Ms. Laura Magliano and Mr. Shannon Gray assisted in the collection and evaluation of the toxicity data. This assessment was funded by a reimbursable contract (FG 1005) with the Department of Pesticide Regulation of the California Environmental Protection Agency. We appreciate the constructive comments on this document received from the California Department of Pesticide Regulation, State Water Resources Control Board, and the Central Valley Regional Water Quality Control Board.

## INTRODUCTION

Methyl parathion is registered for use on a variety of crops, including rice. Methyl parathion use in California for the years of 1975 to 1990 has varied from 7,800 to 46,400 kilograms (kg) on 11,000 to 69,000 hectares (ha) of rice (Table 1). For the past decade there has been concern over the hazard of rice pesticides to aquatic organisms in the Sacramento-San Joaquin Estuary. The discharge of rice pesticides including methyl parathion into the Sacramento-San Joaquin Estuary lasts from May through June (Finlayson et al. in press).

Various assessments on rice pesticides have identified hazards to aquatic organisms in the agricultural drains and the Sacramento-San Joaquin Estuary (Cornacchia et al. 1984; Finlayson and Faggella 1986; Harrington 1990; State Water Resources Control Board [SWRCB] 1990). The Central Valley Regional Water Quality Control Board (CVRWQCB) found toxicity of Colusa Basin Drain water to aquatic invertebrates in 1988 and 1989 (CVRWQCB 1988, 1989). Norberg-King et al. (1991) identified methyl parathion and carbofuran as possible causes of toxicity to cladocerans in Colusa Basin Drain water. The insecticides methyl parathion, carbofuran, and malathion used on rice have also been shown to have additive acute toxicity (Fujimura et al. 1991). A cooperative California Department of Fish and Game (CDFG), California Department of Pesticide Regulation (DPR), and CVRWQCB study in 1990 identified methyl parathion toxicity to mysids in the Colusa Basin Drain (Finlayson et al. in press). Because of hazards to fish and wildlife CDFG has requested, and DPR has agreed, to place methyl parathion use on rice into the formal reevaluation process to allow for the generation of additional data needed to mitigate adverse effects (CDFG 1990).

The CVRWQCB (1990a) adopted performance goals for methyl parathion of 0.26 µg/L for 1991 and 0.13 µg/L for 1992 in waters, including agricultural drains, throughout the Central Valley

Region. CDFG requested the CVRWQCB to lower the proposed performance goal for methyl parathion to less than 0.05 µg/L, the current detection limit (CDFG 1991; 1992). The request was based on a preliminary assessment of the available data on the toxicity of methyl parathion to aquatic organisms. This hazard assessment thoroughly reviews recent data and has resulted in a limit that is more precise than earlier recommendations.

The hazard assessment procedure compares measured environmental concentrations with toxic effects likely to result from those exposures. Environmental concentrations of methyl parathion were measured in the Sacramento River and agricultural drains in 1980 and 1981 (Finlayson and Lew 1982), in 1988 and 1989 (CVRWQCB 1989) and in 1990 (Finlayson et al. in press; Harrington and Lew 1992). Environmental fate data for hydrolysis and photodegradation in soil, water, and air; aerobic and anaerobic soil and aquatic metabolism; volatility; leaching; sorption; and uptake by plants and animals were also reviewed. These data were used to determine pesticide degradation rate, environmental transport, and potential to reach nontarget organisms.

Toxic effects of methyl parathion to aquatic animals were determined by evaluating tests listed in the published literature and public and corporate laboratory reports. Sources of published literature included CDFG Pesticide Investigations Unit library, State of California Resources Agency library, and various state college and university libraries. CDFG also obtained corporate laboratory reports from confidential files which were submitted to DPR in support of pesticide registration.

All available data on methyl parathion were evaluated for conformance with specific criteria described by Harrington (1990). Each test was screened for test method compliance with standards adapted from the U.S. Environmental Protection Agency (EPA) (1985), and the American Society of Testing and Materials (ASTM 1987, 1988a, 1988b, 1989). Although tests did not have to comply with

all requirements, tests were rejected if they did not follow certain fundamental procedures such as maintaining proper organism survival in a control treatment, or conducting tests only with unstressed, healthy organisms. Tests which did not contain sufficient information for proper evaluation were also rejected if attempts to obtain the missing information from the original researcher failed. The Water Quality Criterion (WQC) was calculated using data from acceptable tests, according to procedures described and recommended by the EPA (1985).

Table 1. Methyl parathion use on rice in California, 1975-1990. Data from DPR Pesticide Use Report Database.

| year | kg | ha |
|---|---|---|
| 1975 | 10,664 | 14,853 |
| 1976 | 8,936 | 13,769 |
| 1977 | 7,843 | 10,992 |
| 1978 | 20,388 | 27,215 |
| 1979 | 30,304 | 46,559 |
| 1980 | 44,100 | 65,911 |
| 1981 | 45,909 | 66,397 |
| 1982 | 46,364 | 68,826 |
| 1983 | 27,273 | 31,174 |
| 1984 | 33,454 | 43,563 |
| 1985 | 21,591 | 28,745 |
| 1986 | 22,136 | 30,125 |
| 1987 | 25,909 | 34,170 |
| 1988 | 32,500 | 42,510 |
| 1989 | NA[a] | NA |
| 1990 | 24,322 | 31,822 |

[a] Not available

## ENVIRONMENTAL FATE

Methyl parathion is an organophosphate insecticide soluble in water at 50 mg/L at a temperature of 25°C. At pH 1 to 5 and a temperature of 20°C, the $t_{1/2}$ (hydrolysis) value is 175 days. Degradation is more rapid in biologically active water. In raw river water, 75% of methyl parathion degraded in one week. (Kronenberg et al. n.d.)

A reaction of methyl parathion in light is oxidation to methyl paraoxon, which is the active cholinesterase-inhibiting compound (Kronenberg et al. n.d.). However, methyl paraoxon constituted less than 1% of methyl parathion found in rice field water (Kollman et al. 1992).

Hydrolysis of methyl parathion or methyl paraoxon yields p-nitrophenol and dimethyl phosphorothioate. In soils, methyl parathion degrades rapidly by hydrolysis and oxidation. Microbial action most likely enhances the rapid degradation of methyl parathion in soil. Methyl parathion is usually considered to be too unstable for accumulation in the tissues of land animals, although residues in wildlife have been reported. (Kronenberg et al. n.d.)

Kollman et al. (1992) determined that methyl parathion dissipation in rice fields followed a biphasic dissipation model with respective phase one and phase two $t_{1/2}$ values of 1.0 and 4.7 days.

## ACUTE TOXICITY TO AQUATIC ANIMALS

The EPA (1985) guidelines recommend eight categories of freshwater organisms from which data should be available for deriving a freshwater Final Acute Value (FAV), and eight categories

of saltwater organisms for deriving a saltwater FAV (Table 2); the EPA (1985) procedure is silent on deriving an estuarine FAV. Because the Sacramento River system includes the Sacramento-San Joaquin Estuary, the FAV must protect both fresh and saltwater species. The previous hazard assessment on rice herbicides combined values for saltwater, estuarine, and freshwater organisms (Harrington 1990). The EPA freshwater and saltwater lists of recommended categories of organisms were combined into a set of nine categories of species (Table 3). Although a deviation from EPA (1985) guidelines, the combined list meets EPA taxa requirements, both freshwater and saltwater species are represented, and the list represents a broader spectrum of sensitivity to methyl parathion.

Twenty-five studies on the acute toxicity of methyl parathion to aquatic animals were evaluated using CDFG guidelines described by Harrington (1990, 1991) for use in deriving the FAV (Appendix A). Eight of these studies were accepted (Table A-1), and seventeen of these studies were not accepted (Table A-2). Accepted tests were available for seven of the nine combined freshwater and saltwater categories of organisms adapted from EPA (1985) recommendations. To fill the two remaining categories, acceptable tests would be necessary for (a) a family not in phylum Arthropoda or Chordata, and (b) another insect, or a phylum not represented.

Although data were lacking for two categories of organisms, EPA (1985) procedures as described by Harrington (1990) were used to calculate an interim FAV. Values from accepted acute toxicity tests were ranked in ascending order (Table 4). Values ranged from 0.15 µg/L as the 48-h $EC_{50}$ for the cladoceran *Daphnia magna* to 75,800 µg/L as the 96-h $LC_{50}$ for the northern puffer *Sphaeroides maculatus*. The lowest four values are the most significant determinants of the FAV (Appendix C), and these values were for sensitive invertebrates. The interim FAV for methyl parathion was

0.17 µg/L. This value approximates the Genus Mean Acute Value (GMAV) (0.15 µg/L) for the cladoceran, *Daphnia magna*.

Table 2. Eight categories of species recommended by EPA (1985) for deriving freshwater and saltwater Final Acute Values (FAV).

| Freshwater FAV | Saltwater FAV |
|---|---|
| 1. One Salmonid family | 1, 2. Two families in phylum Chordata |
| 2. Another family in class Osteichthyes | |
| 3. Another family in phylum Chordata | 3. One family not in phylum Arthropoda or Chordata |
| 4. One family not in phylum Arthropoda or Chordata | 4, 5, 6. Three other families not in Chordata |
| 5. One insect family or any phylum not already represented | |
| 6. One planktonic crustacean | |
| 7. One benthic crustacean | 7. A mysid or penaeid family |
| 8. One insect | 8. One other family not already represented |

Table 3. Nine categories of species for deriving a Final Acute Value for the Sacramento-San Joaquin Estuary, and list of corresponding animals used for methyl parathion.

| Category of Species | Animal |
|---|---|
| 1. Family Salmonidae | Rainbow trout |
| 2. Another family in class Osteichthyes | Bluegill |
| 3. Another family in phylum Chordata | Yellow perch |
| 4. Family in not phylum Arthropoda or Chordata | [a] |
| 5. Family Mysidae or Penaeidae | Mysid |
| 6. Planktonic crustacean | Cladoceran |
| 7. Benthic crustacean | Crayfish |
| 8. An insect | Damselfly |
| 9. Another insect, or a phylum not represented | [a] |

[a] acceptable test not available for this category

Table 4. Ranked Genus Mean Acute Values (GMAVs) from accepted acute toxicity tests on methyl parathion.

| Rank | GMAV | Species |
|---|---|---|
| 1 | 0.15[a] | Cladoceran<br>*Daphnia magna* |
| 2 | 0.20[a] | Mysid[b]<br>*Neomysis mercedis* |
| 3 | 0.37 | Cladoceran<br>*Simocephalus serrulatus* |
| 4 | 2.0 | Sand shrimp<br>*Crangon septemspinosa* |
| 5 | 2.6 | Cladoceran<br>*Ceriodaphnia dubia* |
| 6 | 3.0 | Grass shrimp<br>*Palaemonetes vulgaris* |
| 7 | 4.0[a] | Amphipod<br>*Gammarus fasciatus* |
| 8 | 7.0 | Hermit crab<br>*Pagurus longicarpus* |
| 9 | 15.0 | Crayfish<br>*Orconectes nais* |
| 10 | 33.0 | Damselfly<br>*Ischura venticalis* |
| 11 | 890 | Copepod<br>*Acartia tonsa* |
| 12 | 3,060 | Yellow perch<br>*Percan flavescens* |
| 13 | 3,564[a] | Lake trout<br>*Salvelinus namaycush* |
| 14 | 3,600[a] | Striped bass[b]<br>*Morone saxatilis* |
| 15 | 3,700 | Western chorus frog[b]<br>*Psuedacris triseriata* |

Table 4- Continued -2-

| Rank | GMAV | Species |
|---|---|---|
| 16 | 3,703[c] | Genus: *Oncorhynchus*<br>Rainbow trout[b] (3,190)<br>*Oncorhynchus mykiss*<br>Cutthroat trout(3,005)<br>*Oncorhynchus clarki*<br>Coho salmon (5,300)<br>*Oncorhynchus kisutch* |
| 17 | 4,700 | Brown trout<br>*Salmo trutta* |
| 18 | 5,200 | Striped mullet<br>*Mugil cephalus* |
| 19 | 5,220 | Largemouth bass[b]<br>*Micropterus salmoides* |
| 20 | 5,700 | Atlantic silverside<br>*Menidia* |
| 21 | 5,899[c] | Genus: Ictalurus<br>Black bullhead[b] (6,640)<br>*Ictalurus melas*<br>Channel catfish[b] (5,240)<br>*Ictalurus punctatus* |
| 22 | 6,150[c] | Genus: *Lepomis*<br>Bluegill[b] (5,497)<br>*Lepomis macrochirus*<br>Green sunfish[b] (6,880)<br>*Lepomis cyanellus* |
| 23 | 7,130 | Carp[b]<br>*Cyprinus carpio* |
| 24 | 7,800[a] | Fathead minnow[b]<br>*Pimephales promelas* |
| 25 | 9,000 | Goldfish[b]<br>*Carrassius auratus* |
| 26 | 12,300 | Bluehead<br>*Thalassoma bifasciatum* |

Table 4- Continued -3-

| Rank | GMAV | Species |
|---|---|---|
| 27 | 16,900 | American eel<br>*Anguilla rostrata* |
| 28 | 28,300[c] | Genus: *Fundulus*<br>Mummichog (58,000)<br>*Fundulus heteroclitus*<br>Striped killifish (13,800)<br>*Fundulus majalis* |
| 29 | 75,800 | Northern puffer<br>*Sphaeroides maculatus* |

[a] geometric mean of values from several toxicity tests on this species; individual values are listed in Table A-1

[b] occurs in Sacramento-San Joaquin Estuary

[c] geometric mean of values from toxicity tests on several species in this genus; individual values are in parenthesis and are listed in Table A-1.

## CHRONIC TOXICITY TO AQUATIC ANIMALS

Five tests on the chronic toxicity of methyl parathion were evaluated for use in deriving the FCV (Appendix B). Three of these tests were accepted (Table B-1), and two of these tests were not accepted (Table B-2).

The No Observable Effect Concentration (NOEC) values from acceptable tests ranged from 0.17 to 310 µg/L methyl parathion for 21-d exposure to the cladoceran *Daphnia magna* and 32-d exposure to fathead minnow *Pimephales promelas*, respectively (Table B-1). The Lowest Observable Effect Concentrations (LOEC) values ranged from 0.7 µg/L to 380 µg/L for *D. magna* and *P. promelas*, respectively. The Maximum Acceptable Toxicant Concentration (MATC) values (NOEC X LOEC)$^{1/2}$ ranged from 0.34 for *Daphnia magna* to 343 µg/L for fathead minnow.

The EPA (1985) specifies two methods for calculating the FCV. If chronic toxicity data are available for all the categories of organisms described for the FAV, the same method may be used for calculating the FCV. If sufficient data are not available, the FCV is obtained by dividing the FAV by an Acute-to-Chronic Ratio (ACR). An ACR is obtained by dividing the MATC value from a chronic toxicity test by the acute toxicity value for that species. A final ACR (FACR) is normally calculated as the geometric mean for at least a fish, an invertebrate, and an acutely sensitive species. Currently, acute and chronic test data are available for one fish and two invertebrates (Table 5). However, data for the cladoceran *Daphnia magna* indicate that acute toxicity occurs at lower concentrations than chronic toxicity, so *D. magna* data were not used to calculate the FACR.

As with other organophosphate and carbamate insecticides, ACR values appear to increase with increased acute values (Table 5). EPA (1985) procedures specify that when ACR values increase or decrease in direct relation to acute values, the geometric mean of the ACR values for those species whose acute values are close to the FAV should be used as the FACR. This is consistent with other observations on cladocerans which show similar acute and chronic toxicities for insecticides (Norberg-King et al. 1991). An ACR of 2.2 was derived from tests with the cladoceran *C. dubia*. Using an ACR based on responses from a cladoceran is reasonable because cladocerans make up three of the five lowest acute values. The interim FCV for methyl parathion of 0.08 µg/L was estimated by dividing the interim FAV of 0.17 µg/L by the ACR of 2.2.

## TOXICITY TO AQUATIC PLANTS

No tests on the toxicity of methyl parathion to aquatic plants were available. However, because methyl parathion is an insecticide applied to plants, it is reasonable to expect methyl parathion to be less toxic to plants than to animals.

Table 5. Acute-to-Chronic Ratio (ACR) values for invertebrates and fish exposed to methyl parathion.

| Species | Acute value (µg/L) | Chronic value (µg/L) | References | ACR |
|---|---|---|---|---|
| Cladoceran *Daphnia magna* | 0.15 | 0.34 | Mayer and Ellersieck 1986; Cheminova 1987 | 0.47 |
| Cladoceran *Ceriodaphnia dubia* | 2.6 | 1.2 | Norberg-King et al. 1991 | 2.2 |
| Fathead minnow *Pimephales promelas* | 5,360 | 343 | Jarvinen and Tanner 1982 | 15.6 |

## HAZARD ASSESSMENT

### Water Quality Criterion

The most sensitive species tested were the cladoceran *Daphnia magna* with a GMAV of 0.15 µg/L and the mysid *Neomysis mercedis* with a GMAV of 0.20 µg/L. Mysids and cladocerans are important food items for many young fish including striped bass in the Sacramento-San Joaquin Estuary (Stevens et al. 1985; Knutson and Orsi 1983), and the CDFG WQC guidelines are intended to provide full protection to sensitive resident species (Harrington 1990). The interim FCV of 0.08 µg/L methyl parathion should provide protection for the mysids and cladocerans and is proposed as the interim WQC for the Sacramento River system. The recommended interim WQC represents a maximum rather than an average concentration. Organisms normally respond to average concentrations. The maximum concentration of methyl parathion measured in the environment is approximately twice the average concentration measured for the 30-day exposure, and thus provides a two-fold margin of safety.

The interim WQC proposed in this assessment is based on the toxicity of methyl parathion alone. Reevaluation of the interim WQC may be necessary because methyl parathion, carbofuran, and malathion, three insecticides used on rice and found concurrently in the Sacramento River system, have demonstrated additive acute toxicity to the mysid and striped bass (Fujimura et al. 1991). An acceptable level (AL) of methyl parathion in the environment in the presence of the other two insecticides would be less than the 0.08 µg/L proposed here because of cumulative toxicity. Additive toxicity occurs when the observed toxicity for a mixture is equal to the sum of the potential toxicity of the individual components. If there were additive chronic toxicity among the insecticides, acceptable levels in the environment would be represented by the equation: AL/WQC (methyl parathion) + AL/WQC

(carbofuran) + AL/WQC (malathion) = 1. This approach was used by Harrington (1990) in assessing rice herbicide toxicity and by CVRWQCB (1990b) in determining deleterious levels of pesticides in surface waters. There is no information on the influence rice herbicides have on the toxicity of rice insecticides and vice versa. Reevaluation of the interim WQC will also be necessary when the acute and chronic toxicity data gaps (see below) are filled.

**Hazard to Aquatic Animals**

A review of acute and chronic toxicity values for methyl parathion indicates that a hazard to sensitive aquatic invertebrates, especially mysids and cladocerans, has existed in the agricultural drains and may have existed in the Sacramento River. Toxicological hazard to fish probably is not present in the Sacramento River system because acute toxicity values for fish are >1,800 µg/L and exposure levels have rarely exceeded 3.0 µg/L in the agricultural drains.

Concentrations of methyl parathion were first measured in the agricultural drains in 1980 and 1981 (Finlayson and Lew 1982). Concentrations ranged from 0.2 to 2.9 µg/L for the period of June through July 1980 and from 1.0 to 3.7 for the period of May through June 1981. These were over ten-fold higher than acute values to sensitive aquatic invertebrates. Concentrations of methyl parathion were detected periodically in the agricultural drains (0.1 to 1.8 µg/L) and the Sacramento River (0.01 to 0.32 µg/L) near the city of Sacramento during April through June 1988 (CVRWQCB 1989). A survey conducted by CDFG and DPR found concentrations of methyl parathion in agricultural drains (0.13 to 0.66 µg/L) during a four-week period of May through June 1990 (Finlayson et al. in press). Methyl parathion was not detected (≥0.1 µg/L) in the Sacramento River near Rio Vista during the same period in 1990.

Monitoring data are not available but concentrations of methyl parathion could have approached or exceeded 0.08 µg/L in the Sacramento-San Joaquin Estuary during the early 1980s. Agricultural drain water from rice fields can constitute up to 25% of the total flow in the Sacramento River below the city of Sacramento (SWRCB 1990; Cornacchia et al. 1984) and levels of methyl parathion have been as high as 3.7 µg/L in the agricultural drains. These drain levels could have resulted in methyl parathion concentrations up to 0.94 µg/L in the Sacramento River below the city of Sacramento for periods of up to four weeks. However, it is unlikely that levels this high would occur in the future because the use of methyl parathion, and the discharge of field water potentially containing methyl parathion, are now regulated more strictly.

**Data Requirements**

Data were available for seven of the nine categories of species adapted from EPA (1985) recommendations for use in deriving a FAV (Table 3). Acceptable acute tests are needed for one species in a phylum other than Arthropoda or Chordata and another phylum not represented or a second insect (Table 6). To derive a FAV, acute toxicity tests should be performed with juvenile stonefly *Pteronarcys californica*, and the larval bay mussel *Mytilus californianus*, representative species resident in the Sacramento River system and the Sacramento-San Joaquin Estuary. Early life-stage chronic toxicity tests should be performed with sheepshead minnow *Cyprinodon variegatus* or rainbow trout *Oncorhynchus mykiss* to better define chronic effects on fish. A chronic toxicity test using either the marine mysid *Mysidopsis bahia* or the estuarine mysid *N. mercedis* is needed to better define the FACR. The species mentioned here would be the most desirable to test, but other resident species that fulfill EPA taxa recommendations would also be acceptable.

Monitoring of the Sacramento-San Joaquin Estuary has been conducted in previous years and should be continued with more sensitive detection limits (<0.05) to help assess the hazard posed by methyl parathion to aquatic species.

Table 6. Minimum required and suggested data for a complete hazard assessment of methyl parathion to aquatic organisms.

| Species[a] | Acute Test | Chronic Test |
|---|---|---|
| Stonefly *Pteronarcys californica* | Required | --- |
| Bay mussel *Mytilus californianus* | Required | --- |
| Sheepshead minnow[b] *Cyprinidon variegatus* | --- | Suggested |
| Rainbow trout[b] *Oncorhynchus mykiss* | --- | Suggested |
| Mysid[c] *Mysidopsis bahia* | --- | Required |
| Mysid[c] *Neomysis mercedis* | --- | Required |

[a] these are the most desirable species to test, but other resident species that fulfill EPA taxa recommendations would also be acceptable,

[b] Either species of fish is suggested for one test,

[c] Either species of mysid is suggested for one test.

## LITERATURE CITED


Albaugh, D. W. 1972. Insecticide tolerances of two crayfish populations (*Procambarus acutus*) in south-central Texas. Bulletin Environmental Contamination Toxicology 8(6):334-338.

American Public Health Association (APHA). 1960. Standard methods for the examination of water and wastewater. 11th Edition. New York, New York.

APHA. 1965. Standard methods for the examination of water and wastewater. 12th Edition. New York, New York.

APHA. 1971. Standard methods for the examination of water and wastewater. 13th Edition. New York, New York.

APHA. 1975. Standard methods for the examination of water and wastewater. 14th Edition. Washington D.C.

American Society for Testing and Materials (ASTM). 1980. Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians. ASTM Committee E-47 Publication E729-80. American Society for Testing and Materials, Philadelphia, Pennsylvania.

ASTM. 1987. Standard guide for conducting life-cycle toxicity tests with saltwater mysids. ASTM Committee E-47 Publication E1191-87, Philadelphia, Pennsylvania.

ASTM. 1988a. Standard guide for conducting early life-stage toxicity tests with fishes. ASTM Committee E-47 Publication E1241-88, Philadelphia, Pennsylvania.

ASTM. 1988b (1980). Standard practice for conducting acute toxicity tests with fishes, macroinvertebrates, and amphibians. ASTM Committee E-47 (E729-80) Publication E729-88, Philadelphia, Pennsylvania.

ASTM. 1989 (1980). Standard practice for conducting static acute toxicity tests with larvae of four species of bivalve mollusks. ASTM Committee E-47 Publication E724-89 (E724-80), Philadelphia, Pennsylvania.

Brandt, O. M., R. W. Fujimura, B. J. Finlayson. In press. The use of *Neomysis mercedis* (Crustacea:Mysidacea) for estuarine toxicity tests. Transactions American Fisheries Society.

California Department of Fish and Game (CDFG). 1990. Letter to Mr. Henry Voss, Director, California Department of Food and Agriculture, from Mr. Pete Bontadelli, Director, CDFG. Sacramento, California, dated October 9, 1990.

CDFG. 1991. Letter to Mr. William A. Crooks, Executive Officer, Central Valley Regional Water Quality Control Board, from Mr. Pete Bontadelli, Director, CDFG. Sacramento, California, dated February 20, 1991.

CDFG. 1992. Letter to Mr. William A. Crooks, Executive Officer, Central Valley Regional Water Quality Control Board, from Mr. John Turner, Chief, Environmental Services Division, CDFG. Sacramento, California, dated February 13, 1992.

Carter, F. L., and J. B. Graves. 1973. Measuring effects of insecticides on aquatic animals. Louisiana Agriculture 16(2):14-15.

Central Valley Regional Water Quality Control Board (CVRWQCB). 1988. Preliminary 1988 Colusa Basin Drain rice growing season biotoxicity results. Memorandum to Jerry Bruns, Chief, Special Studies, Policies & Standards Section, CVRWQCB, from Chris Foe, Environmental Specialist, CVRWQCB, Sacramento, California, dated August 26, 1988.

CVRWQCB. 1989. 1989 Rice season toxicity monitoring results. Memorandum to William H. Crooks, Executive Officer, CVRWQCB, from Rudy Schnagl, Senior Land and Water Use Analyst, CVRWQCB, Sacramento, California, dated October 26, 1989.

CVRWQCB. 1990a. Resolution No. 90-028, Amendment of the Water Quality Control Plan for the Sacramento River (5A), Sacramento-San Joaquin Delta (5B), and San Joaquin (5C) Basins, dated January 26, 1990, Sacramento, California.

CVRWQCB. 1990b. The Water Quality Control Plan (Basin Plan) for the Central Valley Regional Water Quality Control Board (Region 5), Second Edition. Sacramento, California.

Chambers, J. E., and J. D. Yarbrough. 1974. Parathion and methyl parathion toxicity to insecticide-resistant and susceptible mosquitofish (*Gambusia affinis*). Bulletin Environmental Contamination Toxicology. 11(4):315-320.

Chang, V. C. S., and W. H. Lange. 1967. Laboratory and field evaluation of selected pesticides for control of the red crayfish in California rice fields. Journal Economic Entomology 60(2):473-477.

Cheminova. 1987. Influence of methyl parathion on the reproduction rate of *Daphnia magna*. Unpublished report [CDFA document 121-097].

Cheminova. 1989. The toxicity of methyl parathion technical to sheepshead minnow (*Cyprinodon variegatus*) embryos and larvae. Unpublished report [CDFA document 121-072].

Cornacchia, J. W., D. B. Cohen, G. W. Bowes, R. J. Schnagl, B. L. Montoya. 1984. Rice herbicides: molinate and thiobencarb. State Water Resources Control Board, Special Projects Report 84-4, Sacramento, California.

Crossland, N. O. 1984. Fate and biological effects of methyl parathion in outdoor ponds and laboratory aquaria. Ecotoxicology and Environmental Safety 8:482-495.

Doudoroff, P. B. G. Anderson, G. E. Burdick, P. S. Galtsoff, W. B. Hart, R. Patrick, E. R. Strong, E. W. Surber, and W. M. Van Horn. 1951. Bioassay methods for the evaluation of acute toxicity of industrial wastes to fish. Sewage Industrial Wastes 23(11):1380-1397.

Eisler, R. 1969. Acute toxicities of insecticides to marine decapod crustaceans. Crustaceana 16:302-310.

Eisler, R. 1970a. Acute toxicities of organochlorine and organophosphorus insecticides to estuarine fishes. Technical Papers of the Bureau of Sport Fisheries and Wildlife, No. 46.

Eisler, R. 1970b. Latent effects of insecticide intoxication to marine molluscs. Hydrobiologia 36:345.

Finlayson, B. J., G. Faggella. 1986. Comparison of laboratory and field observations of fish exposed to the herbicides molinate and thiobencarb. Transactions American Fisheries Society 115:882-890.

Finlayson B., J. Harrington, R. Fujimura, and G. Isaac. In press. Identification of methyl parathion toxicity in Colusa Basin Drain water. Environmental Toxicology and Chemistry. In press.

Finlayson, B. J., and T. L. Lew. 1982. Colusa Basin Drain and Reclamation Slough monitoring studies, 1980 and 1981. California Department of Fish and Game, Environmental Services Branch Administrative Report No. 82-3, Sacramento, California.

Frear, D. E. H., and J. E. Boyd. 1967. Use of *Daphnia magna* for the microbioassay of pesticides. I. Development of standardized techniques for rearing *Daphnia* and preparation of dose-mortality curves for pesticides. Journal Economic Entomology 60(5):1228-1236.

Fujimura, R. W., B. J. Finlayson, and O. M. Brandt. 1991. Standardized testing program-1990 progress report. Tests No. 9, 17, 24, 31, and 34. California Department of Fish and Game, Aquatic Toxicology Laboratory, Environmental Services Division, Elk Grove, California.

Harrington, J. M. 1990. Hazard assessment of the rice herbicides molinate and thiobencarb to aquatic organisms in the Sacramento River. California Department of Fish and Game, Environmental Services Division Administrative Report No. 90-1, Sacramento, California.

Harrington, J. M. 1991. Procedures used by the California Department of Fish and Game to assess the hazard of pesticides on the state's aquatic resources. Proceedings of the 43rd annual California weed conference. California Weed Conference. Santa Barbara, California.

Harrington, J. M., and T. S. Lew. 1992. Rice pesticide concentrations in the Sacramento River and associated agricultural drains, 1989-1990. California Department of Fish and Game, Environmental Services Division, Administrative Report 92-2, Sacramento, California. (in press).

Hazeltine, W. E. 1963. The development of a new concept for control of the Clear Lake gnat. Journal Economic Entomology 56(5):621-626.

Henderson, C., and Q. H. Pickering. 1958. Toxicity of organic phosphorus insecticides to fish. Transactions American Fisheries Society 87:39-51.

Jarvinen, A. W., and D. K. Tanner. 1982. Toxicity of selected controlled release and corresponding unformulated technical grade pesticides to the fathead minnow *Pimephales promelas*. Environmental Pollution (Series A) 24: 179-195.

Khattat, F. H., and S. Farley. 1976. Acute toxicity of certain pesticides to *Acartia tonsa* Dana. U.S. Environmental Protection Agency, Report No. EPA-600/3-76-033, Narragansett, Rhode Island.

Kollman, W. S., P. L. Wofford, and J. White, 1992. Dissipation of methyl parathion from flooded commercial rice fields. California Department of Pesticide Regulation, Environmental Hazards Assessment Report EH-92-03, Sacramento, California.

Knutson, A. C., and J. J. Orsi. 1983. Factors regulating abundance and distribution of the shrimp *Neomysis mercedis* in the Sacramento-San Joaquin Estuary. Transactions American Fisheries Society 112:476-485.

Kronenberg, F., W. B. Macklin, P. M. Dolinger. n.d. Methyl parathion monograph number seven. Environmental health evaluations of California restricted insecticides. Peter M. Dolinger Associates, Chemical Regulatory Consultants, Menlo Park, California.

Macek, K. J., and W. A. McAllister. 1970. Insecticide susceptibility of some common fish family representatives. Transactions American Fisheries Society 99:20-27.

Mayer Jr., Foster L., and Mark R. Ellersieck. 1986. Manual of acute toxicity: interpretation and database for 410 chemicals and 66 species of freshwater animals. United States Department of the Interior, Fish and Wildlife Service. Resource publication 160. Washington, D.C.

McCann, J. A., and R. L. Jasper. 1972. Vertebral damage to bluegills exposed to acutely toxic levels of pesticides. Transactions American Fisheries Society 101(2):317-322.

Minchew, C. D., and D. E. Ferguson. 1970. Toxicities of six insecticides to resistant and susceptible green sunfish and golden shiners in static bioassays. Journal Mississippi Academy Sciences 15:29-32.

Muncy, R. J., and A. D. Oliver, Jr. 1963. Toxicity of ten insecticides to the red crawfish, *Procambarus clarki* (Girard). Transactions American Fisheries Society 92:428-431.

Murty, A. S., A. V. Ramani, K. Christopher, and B. R. Rajabhushanam. 1984. Toxicity of methyl parathion and fensulfothion to the fish *Mystus cavasius*. Environ. Poll. Series A: Ecological and Biological 34(1):37.

Norberg-King, T. J., E. J. Durhan, and G. T. Ankley. 1991. Application of toxicity identification procedures to the ambient waters of the Colusa Basin Drain, California. Environmental Toxicology Chemistry 10:891-900.

Palawski D., D. Buckler, and F. Mayer. 1983. Survival and condition of rainbow trout *Salmo gairdneri* after acute exposures to methyl parathion, triphenyl phosphate, and DEF. Bulletin Environmental Contamination Toxicology 30:614-620.

Pickering, Q. H., C. Henderson and A. E. Lemke. 1962. The toxicity of organo phosphorus insecticides to different species of warmwater fishes. Transactions American Fisheries Society 91(2): 175-184.

Rehwoldt, R. E., E. Kelley and M. Mahoney. 1977. Investigations into the acute toxicity and some chronic effects of selected herbicides and pesticides on several fresh water fish species. Bulletin Environmental Contamination Toxicology 18(3):361-365.

State Water Resources Control Board (SWRCB). 1990. Sacramento River toxic chemical risk assessment project. Final Project Report 90-11WQ, Sacramento, California.

Stevens, D. E., D. W. Kohlhorst, L.W. Miller, and D.W. Kelley. 1985. The decline of striped bass in the Sacramento-San Joaquin Estuary, California. Transactions American Fisheries Society 114:12-30.

U. S. Environmental Protection Agency (EPA). 1975. Methods for acute toxicity tests with fish, macroinvertebrates, and amphibians. Ecological Research Series Report EPA-600/3-75-009. National Technical Information Service, Springfield, Virginia.

EPA. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. Office of Research and Development, Washington, D.C.

EPA. 1988. Pesticide assessment guidelines, subdivision E, hazard evaluation: wildlife and aquatic organisms. Ecological Effects Branch, Office of Pesticides and Toxic Substances, Washington D.C.

EPA. 1989. Methods for aquatic toxicity identification evaluations: phase III toxicity confirmation procedures. Environmental Monitoring and Support Laboratory Report EPA 600/3-88-036, Cincinnati, Ohio.

Welsh, M. J., and C. W. Hanselka. 1972. Toxicity and sublethal effects of methyl parathion on behavior of Siamese fighting fish (*Betta splendens*). Texas Journal Science 23(4):519-529

APPENDIX A. Abstracts of accepted and unaccepted acute toxicity tests reviewed for hazard assessment.

***Accepted acute toxicity tests*** - The following tests used accepted test methods.

Brandt et al. (in press) - In 1990, 96-h static toxicity tests were performed on methyl parathion (95.7%) using the mysid *Neomysis mercedis*. Tests were conducted with neonates (≤ 5-d postrelease). Neonates were released at the Aquatic Toxicology Laboratory from gravid females collected at Lake Merced, California. Mysids were fed brine shrimp *Artemia salina* nauplii in excess daily. ASTM (1988b) Standard Guide E729-88 was used in performing the static tests. Water quality parameters during the tests were: salinity of 2(±1) g/kg, temperature of 17°C (± 0.5), dissolved oxygen of 90-100% saturation, hardness of 440 mg/L as CaCO3, pH of 8.4, ammonia of <0.05 mg/L, alkalinity of 120 to 140 mg/L as CaCO3. Tests used five treatments of methyl parathion and a control, all in replicate. Solvent and dilution water controls were used; survival was not significantly different between the solvent and dilution water controls. Methyl parathion exposure levels were measured in all treatments at 0 and 96-h. The 96-h $LC_{50}$ values were 0.21 (0.17-0.26) µg/L and 0.20 (0.17-0.23) µg/L.

Eisler (1970a) - From 1964 to 1966, 96-h static toxicity tests were performed on methyl parathion with Atlantic silverside *Menidia menidia*, bluehead *Thalassoma bifasciatum*, striped killifish *Fundulus majalis*, striped mullet *Mugil cephalus*, American eel *Anguilla rostrata*, mummichog *Fundulus heteroclitus*, and northern puffer *Sphaeroides maculatus*. APHA (1960) testing procedures were used. There were solvent (acetone) controls and a minimum of 5 treatments of methyl parathion. Water quality parameters during the test were: temperature of 20 °C, pH of 8.0, dissolved oxygen of 7.1-7.7 mg/L, and salinity of 24 °/∞. Control survival was ≥ 90%. The measurement of methyl parathion exposure levels was not mentioned. The 96-h $LC_{50}$ values were

5,700 µg/L for Atlantic silverside, 12,300 for bluehead, 13,800 for striped killifish, 5,200 for striped mullet, 16,900 for American eel, 58,000 for mummichog and 75,800 for northern puffer.

Eisler (1969) - In 1964, 96-h static toxicity tests were performed on methyl parathion technical (% not given) with the hermit crab *Pagurus longicarpus*, grass shrimp *Paleamonetes vulgaris*, and sand shrimp *Crangon septemspinosa*. American Public Health Association (APHA) (1960) testing procedures were used. There were solvent (acetone) controls and a minimum of 5 treatments of methyl parathion concentrations (serial dilutions). Water quality parameters during the test were: temperature of 20 °C, pH of 8.0, dissolved oxygen of 7.1-7.7 mg/L, and salinity of 24 °/$_{oo}$. Control survival was ≥90%. The measurement of methyl parathion exposure levels was not mentioned. The 96-h $LC_{50}$ values were 7.0 µg/L for the hermit crab, 3.0 µg/L for the grass shrimp and 2.0 µg/L for the sand shrimp.

Fujimura et al. (1991) - In 1990, 96-h static toxicity tests were performed on methyl parathion technical (95.7%) with 33-d and 13-d posthatch striped bass *Morone saxatilis* larvae. ASTM (1988b) testing procedures were used. Five treatments of methyl parathion (dilution factor 0.56) were tested in duplicate with a water and solvent controls. Water quality parameters during the striped bass tests were: temperature of 16.8-17.5 °C, dissolved oxygen of 8.8 to 9.0 mg/L, pH of 8, hardness 420-440 mg/L as $CaCO_3$, alkalinity of 150 mg/L as $CaCO_3$, and salinity of 2 °/$_{oo}$. Control survival ranged from 93 to 97%. Methyl parathion exposure levels were measured at 0 and 96-h in all treatments and controls. The 96-h $LC_{50}$ values were 3,400 µg/L (2,900 to 4,000 µg/L) for 33-d posthatch larvae and 3,088 µg/L (2,822 to 3,402 µg/L) and 4,446 µg/L (4,086 to 5,282 µg/L) for 13-d posthatch larvae striped bass.

Jarvinen and Tanner (1982) - In 1982, a 96-h flow-through toxicity test was performed on technical methyl parathion (80% active ingredient) with larval fathead minnow *Pimephales promelas*. APHA (1975) bioassay standards were used. Five concentrations were duplicated and a control was included. Water quality parameters were: temperature of 23.5-26°C, dissolved oxygen of >75%, hardness of 45.8 mg/L, alkalinity of 43.1 mg/L, and pH of 7.4-7.8. Control survival was 100% Methyl parathion exposure levels were measured, and measured levels were 92.0± 7.7% of nominal. The 96-h $LC_{50}$ value was 5.36 mg/L.

Khattat and Farley (1976) - In 1972, a 96-h static toxicity test was performed on methyl parathion technical (80%) with the mature copepod *Acartia tonsa*. There were solvent (acetone) and seawater controls and 6 treatments of methyl parathion (dilution factors of 0.1 to 0.5) were tested with 4 replicates. Water quality parameters during the test were: temperature of 17 °C, dissolved oxygen of ≥ 80% saturation, and salinity of 20 °/$_{oo}$. Control survival was 87.5% for acetone and 90% for seawater. Methyl parathion exposure levels were measured at the end of the test. The 96-h $LC_{50}$ value was 890 µg/L (685 to 1,163 µg/L).

Mayer and Ellersieck (1986) - In 1986, a study was conducted by the Fish and Wildlife Service to compile static acute toxicity test data for 410 chemicals with 66 freshwater species. All tests were done at the Columbia National Fisheries Research Laboratory and its field laboratories between 1965-1984. The studies compiled on technical methyl parathion were conducted with 20 species. The tests were generally in compliance with to ASTM (1980) and EPA (1975) standards. At least five concentrations of methyl parathion were duplicated in each test. Water quality parameters ranged, depending on species, between: temperature 12-22°C, pH 7.1-7.4, and hardness 44-272 mg/L. Control survival, dissolved oxygen, and measurement of methyl parathion exposure levels were not discussed. The 96-h $LC_{50}$ values are listed in table A-1. Although this study did not

include some essential test characteristics, most of these data were accepted because of using ASTM guidelines and the integrity of the agency. The third fathead minnow test conducted with 77% a.i. formulation, however, was not accepted due to low active ingredient content.

Norberg-King et al. (1991) - In 1988, a renewal 48-h acute toxicity test was conducted with technical methyl parathion (99.7% active ingredient) on $\leq$ 4-h old neonate *Ceriodaphnia dubia*. EPA (1989) bioassay guidelines were used. Five concentrations were tested and a water control was included. Water quality parameters were: temperature of 25$\pm$ 1°C, dissolved oxygen "adequate", pH of 7.9, and hardness of 45-50 mg/L as $CaCO_3$. Methyl parathion exposure levels were measured. Control survival in was 100%. The 48-h $EC_{50}$ value was 2.6 (2.1-3.1) µg/L.

***Unaccepted acute toxicity tests*** - The following tests did not use accepted test methods and/or produce accepted results.

Albaugh (1972) - In 1972, 48-h static toxicity tests were performed on methyl parathion technical (% not given) with insecticide susceptible and resistant White River crawfish *Procambarus acutus*. There was a solvent (acetone) control and 3-5 treatments of methyl parathion ranging from 1-10 µg/L. Water quality parameters during the test were: pH of 8.7, and hardness of 10 mg/L as $CaCO_3$. Control survival was 100%. The measurement of methyl parathion exposure levels and most water quality parameters were not mentioned. The 48-h $LC_{50}$ values were 2.4 (1.9-3.0) µg/L for crayfish collected from a "clean area" and 3.4 (3.0-4.0) µg/L for crayfish collected from a cotton field area. These values were not used because the report lacked essential information on test conditions and did not follow standard procedures.

Carter and Graves (1973) - In 1973, 96-h and 24-h static bioassays were performed on methyl parathion (% not given) with

White River crawfish *Procambarus acutus*, bluegill *Lepomis macrochirus*, mosquitofish *Gambusia affinis*, channel catfish *Ictalurus punctatus*, and bullfrog tadpoles *Rana catesbeiana*. APHA (1971) testing procedures were used. Tests were performed with 5 replicates for crawfish and 2 replicates for the other species. Water quality parameters during the test were: temperature of 23-26 °C, and dissolved oxygen of 7-10 mg/L. Controls, control survival, concentration scale, and measurement of methyl parathion exposure levels were not mentioned. The 96-h $LC_{50}$ values ranged from 3-9,360 µg/L. These values were not used because the report lacked essential information including control survival.

Chambers and Yarbrough (1974) - In 1974, 48-h static toxicity tests were performed on technical methyl parathion (99%) with susceptible and resistant mosquitofish *Gambusia affinis*. There was a solvent (methoxyethanol) control and an unspecified number of treatments of methyl parathion ranging from 12,000 to 17,000 µg/L. Water quality parameters during the test were not given. Control survival and measurement of methyl parathion exposure levels were not mentioned. The 48-h $LC_{50}$ values were 13,480 µg/L (13,240-13,720 µg/L) for fish collected from ponds having no insecticide exposure and 17,480 µg/L for fish collected from cotton field drainage ditches. These values were not used because the test did not follow standard exposure (test duration not 96-h), lacked essential information including control survival, and used test organisms which were collected from the field and acclimated for only 24 hours.

Chang and Lange (1967) - In 1966, 36-h static toxicity tests were performed on methyl parathion emulsifiable concentrate (51%) with red crawfish *Procambarus clarki*. Five treatments of methyl parathion were tested with 5 replicates and 5 controls. Water quality parameters during the test were: temperature of 22.2-25.5 °C (other parameters not given). Control survival and measurement of methyl parathion exposure levels were not

mentioned. The 36-h $LC_{50}$ value was 41 µg/L. This value was not used because the report lacked essential information including control survival, did not follow standard test exposures (test duration not 96-h), and used a formulated product which had a low percentage of active ingredient and high percentage of solvents.

Eisler (1970b) - In 1970, 96-h static toxicity tests were conducted on methyl parathion technical (100%) with adult quahog or hard-shelled clams *Mercenaria mercenaria* and adult mud snails *Nassa obsoleta*. There was a water control and 4 treatments of methyl parathion with 3 replicates for the clams only. Water quality parameters during the test were: temperature of 20 °C, pH of 8.0, and salinity of 24 °/$_{oo}$. Control survival was 100%. Measurement of methyl parathion exposure levels was not mentioned. There were no deaths for either species at the highest concentration tested; the $LC_{50}$ values were >25,000 µg/L. These values were not used because the study did not follow standard procedure and lacked essential information. It is also possible that these adult mollusks avoided exposure by withdrawing the body inside the shell.

Frear and Boyd (1967) - Between 1955 and 1960, a 26-h static toxicity test was performed on methyl parathion (% not given) with the cladoceran *Daphnia magna*. There were solvent (acetone) controls and 4 treatments of methyl parathion (dilution factor 0.1) with 10 replicates. Water quality parameters during the test, control survival and measurement of methyl parathion exposure levels were not mentioned. The 26-h $LC_{50}$ value was 4.8 µg/L. This value was not used because the report lacked essential information including control survival and did not follow standard test exposures (test durations not 48-h).

Hazeltine (1963) - In 1962, 24-h static toxicity tests were performed on methyl parathion technical (80%) with larval Clear Lake gnat *Chaoborus astictopus*. There was a control and unspecified number of treatments of methyl parathion with 3

replicates. Water quality parameters during the test were: temperature of 23 °C (other parameters not given). Any test with significant control mortality was discarded. Measured concentrations of methyl parathion were not mentioned. The 24-h $LC_{50}$ values were from 5.8 µg/L for 4th instar to 1.2 µg/L for 1st instar. These values were not used because the report lacked essential information and did not follow standard test exposures (test duration not 48-h or 96-h).

Henderson and Pickering (1958) - In 1957, 96-h static tests were performed on methyl parathion technical (80%) with fathead minnows *Pimephales promelas*. Federation of Sewage and Industrial Wastes Association (Doudoroff et al. 1951) testing procedures were used. Tests were performed in both hard and soft water. There was a logarithmic series of 5 treatments of methyl parathion (dilution factor 0.6) conducted in duplicate. Water quality parameters during the test were: temperature of 25 °C, pH of 7.4 (soft) and 8.2 (hard), dissolved oxygen of 8.0 mg/L, hardness of 20 (soft) and 400 (hard) as mg/L $CaCO_3$, and alkalinity of 18 (soft) and 360 (hard) as mg/L $CaCO_3$. Control survival and measurement of methyl parathion exposure levels were not mentioned. The 72-h $LC_{50}$ values were 10,400 (soft) and 9,400 (hard) µg/L. These values were not used because the report lacked essential information including control survival.

Macek and McAllister (1970) - In 1970, 96-h static toxicity tests were performed on methyl parathion technical (80%) with juvenile channel catfish *Ictalurus punctatus* and juvenile redear sunfish *Lepomis microlophus*. Ten other species were tested and included in the Mayer and Ellersieck (1986) study. There was a solvent (acetone) control and a minimum of 6 treatments of methyl parathion. Methyl parathion exposure level measurements and control survival were not mentioned. Water quality parameters during the tests were: temperature of 18±0.5 °C, pH of 7.1, and alkalinity of 35 mg/L as $CaCO_3$. The 96-h $LC_{50}$ values for channel catfish and redear sunfish were 5,710 (4,190-7,800) and 5,170

(4,410- 6,090) µg/L, respectively. These values were not used because the report lacked essential information including control survival.

McCann and Jasper (1972) - In 1972, a 24-h static toxicity test was performed on methyl parathion technical (44.6%) with bluegill *Lepomis macrochirus*. APHA (1965) testing procedures were used. Water quality parameters during the tests were: temperature of 18 °C, pH of 7, hardness of 51.3 mg/L as $CaCO_3$, and alkalinity of 41.04 mg/L as $CaCO_3$. Controls, control survival, and measurement of methyl parathion exposure levels were not mentioned. The 24-h $LC_{50}$ value was 6,470 µg/L. This value was not used because the report lacked essential information including control survival and did not follow standard test exposures (test duration not 96-h).

Minchew and Ferguson (1970) - In 1970, 48-h static toxicity tests were performed on methyl parathion technical (% not given) with susceptible and resistant green sunfish *Lepomis cyanellus* and golden shiners *Notemigonus crysoleucas*. There were solvent (acetone) controls and 4 to 5 treatments of methyl parathion tested in duplicate. Water quality parameters during the test were: temperature of 20 °C. Control survival and measurement of methyl parathion exposure levels, and other water quality parameters were not mentioned. The 48-h $LC_{50}$ values were above 5,000 µg/L, for susceptible and resistant green sunfish and golden shiners. These values were not used because the report lacked essential information including control survival and did not follow standard test exposures (test duration not 96-h).

Muncy and Oliver (1963) - In 1963, a 72-h static toxicity test was performed on methyl parathion technical (% not given) with red crawfish *Procambarus clarki*. APHA (1960) testing procedures were used. A control and an unspecified number of treatments of methyl parathion were tested. Measurement of methyl parathion exposure levels was not mentioned. Water quality parameters

during the tests were: temperature of 16-32 °C, pH of 7.6, and alkalinity of 8 mg/L as $CaCO_3$. The 72-h $LC_{50}$ value was 40 µg/L. These values were not used because the test lacked essential information including control survival and did not follow standard test exposures (test duration not 96-h).

Murty et al. (1984) - In 1983, a 96-h flow-through toxicity test was performed on methyl parathion technical (% not given) with juvenile freshwater catfish *Mystus cavasius*. Testing methods described by EPA (1975) were used. There was a solvent (acetone) control and 6 treatments of methyl parathion (dilution factor 0.8) tested in triplicate. Water quality parameters during the test were: temperature of 28±2 °C, dissolved oxygen of 7-8 mg/L, pH of 8.4, hardness of 123 mg/L as $CaCo_3$ and alkalinity of 304 mg/L as $CaCo_3$. Control survival and measurement of methyl parathion exposure levels were not mentioned. The 96-h $LC_{50}$ value was 5,900 µg/L (5,400-6,500 µg/L). This value was not used because it lacked essential testing methods and results, including control survival.

Palawski et al. (1983) - In 1982, a 96-h static toxicity test was performed on methyl parathion technical (76.8%) with 12-d posthatch rainbow trout *Oncorhynchus mykiss*. Testing procedures described by EPA (1975) were used. There were solvent and dilution water controls and three treatments of methyl parathion (2.1-2.8 mg/L). Water quality parameters during the test were: temperature of 12±1 °C, pH of 7.5, hardness of 272 mg/L $CaCO_3$ and alkalinity of 237 mg/L as $CaCO_3$. Control survival was 100% for both controls. Measurement of methyl parathion exposure levels was not mentioned. The 96-h $EC_{50}$ and $LC_{50}$ was 2,000 (1,700-2,300) and 2,800 µg/L (2,200-3,500 µg/L), respectively. These values were not used because it lacked a sufficient number and range of methyl parathion concentrations for acceptable $LC_{50}$ calculation.

Pickering et al. (1962) - In 1962, 96-h static toxicity tests were performed on methyl parathion technical (80%) with fathead

minnow *Pimephales promelas*, bluegill *Lepomis macrochirus*, guppies *Lebistes reticulatus*, and goldfish *Carassius auratus*. APHA (1960) testing procedures were used. There were logarithmic series of treatments of methyl parathion tested in duplicate. Water quality parameters during the test were: temperature of 25 °C, pH of 7.4-7.5, dissolved oxygen of 8.0 mg/L, hardness of 20 mg/L $CaCO_3$, and alkalinity of 18 mg/L as $CaCO_3$. Controls, control survival, and measurement of methyl parathion exposure levels were not mentioned. The 96-h $LC_{50}$ values ranged from 2,400-12,000 µg/L. These values were not used because the report lacked essential information including control survival.

Rehwoldt et al. (1977) - In 1977, 96-h toxicity tests were conducted on methyl parathion (% not given) with striped bass *Morone saxatilis*, pumpkinseed *Lepomis gibbosus*, American eel *Anguilla rostrata*, white perch *Roccus americanus*, banded killifish *Fundulus diaphanus*, guppy *Libistes reticulatus* and carp *Cyprinus carpio*. Water quality parameters during the test were: temperature of 20 °C, pH of 7.2, dissolved oxygen of 6.0 mg/L, and hardness of 50 mg/L as $CaCO_3$. Materials and methods were not given for the study. Control survival and measurement of methyl parathion exposure levels were not mentioned. The 96-h $LC_{50}$ values ranged from 3,600-15,200 µg/L. These values were not used because the test lacked essential information including control survival and methodology.

Welsh and Hanselka (1972) - In 1972, a 120-h static toxicity test was conducted on methyl parathion (% not given) with Siamese fighting fish *Betta splendens*. There was a solvent (hexane) control and 4 treatments of methyl parathion (dilution factor of 0.9). Water quality parameters during the test were: temperature of 25 °C, and pH of 7.0-7.4. Methyl parathion exposure levels were measured "periodically". Control survival was not mentioned. The 120-h $LC_{50}$ value was between 7,500 and 8,000 µg/L (determined graphically). The study also measured effects on "displaying" behavior (spreading of fins and opercula) which

showed no significant difference from control fish. This value was not used because the report did not follow standard exposures (test duration not 96-h), lacked essential information including control survival, and the species is not found in North American waters.

Table A-1. Values (µg/L) from accepted tests on the acute toxicity of methyl parathion to aquatic animals.

| Species | Life Stage[a] | Method[b] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.)[c] | Reference |
|---|---|---|---|---|---|---|---|---|
| American eel *Anguilla rostrata* | Juv | S, U | Tech (-) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | 16,900 | Eisler 1970a |
| Amphipod *Gammarus fasciatus* | Adult | S, M | Tech (90%) | 40-50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 3.8 (2.6-5.5) | Mayer and Ellersieck 1986 |
| Amphipod *Gammarus fasciatus* | Adult | S, U | Tech (90%) | 272 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 4.3 (3.6-5.2) | Mayer and Ellersieck 1986 |
| Atlantic silverside *Menidia menidia* | Juv | S, U | Tech (-) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | 5,700 | Eisler 1970a |
| Black bullhead *Ictalurus melas* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 6,640 (4,970-8,880) | Mayer and Ellersieck 1986 |
| Bluegill *Lepomis machrochirus* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 4,380 (3,480-5,510) | Mayer and Ellersieck 1986 |
| Bluegill *Lepomis machrochirus* | n/a | S, U | Tech (90%) | 272 mg/L | 96-h | $LC_{50}$ | 6,900 (6,400-7,440) | Mayer and Ellersieck 1986 |
| Bluehead *Thalassoma bifasciatum* | Juv | S, U | Tech (-) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | 12,300 | Eisler 1970a |
| Brown trout *Salmo trutta* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 4,700 (3,900-5,750) | Mayer and Ellersieck 1986 |
| Carp *Cyprinus carpio* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 7,130 (6,440-7,870) | Mayer and Ellersieck 1986 |
| Channel catfish *Ictalurus punctatus* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 5,240 (4,270-6,440) | Mayer and Ellersieck 1986 |
| Cladoceran *Ceriodaphnia dubia* | neonate | S, M | Tech (99.7%) | 45-50 mg/L $CaCO_3$ | 48-h | $EC_{50}$ | 2.6 (2.1-3.1) | Norberg-King et al. 1991 |

Table A-1. continued-2

| Species | Life Stage | Method[a] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.) | Reference |
|---|---|---|---|---|---|---|---|---|
| Cladoceran *Daphnia magna* | 1st instar | S, M | Tech (98.7%) | 44 mg/L $CaCO_3$ | 48-h | $EC_{50}$ | 0.14 (0.09-0.20) | Mayer and Ellersieck 1986 |
| Cladoceran *Daphina magna* | 1st instar | S, U | Tech (90.0%) | 272 mg/L | 48-h | $EC_{50}$ | 0.16 (0.110-0.240) | Mayer and Ellersieck 1986 |
| Cladoceran *Simocephalus serrulatus* | 1st instar | S, M | Tech (98.7%) | 44 mg/L $CaCO_3$ | 48-h | $EC_{50}$ | 0.37 (0.23-0.57) | Mayer and Ellersieck 1986 |
| Coho salmon *Oncorhynchus kisutch* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 5,300 (4,900-5,600) | Mayer and Ellersieck 1986 |
| Copepod *Acartia tonsa* | Adult | S, M | Tech (80%) | 20 °/$_{oo}$ | 96-h | $LC_{50}$ | 890 (685-1,163) | Khattat and Farley 1976 |
| Crayfish *Orconectes nais* | Adult | S, M | Tech (98.7%) | 162-272 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 15.0 | Mayer and Ellersieck 1986 |
| Cutthroat trout *Oncorhynchus clarki* | n/a | S, U | Tech (90%) | 162 mg/L | 96-h | $LC_{50}$ | 1,850 (1,390-2,740) | Mayer and Ellersieck 1986 |
| Cutthroat trout *Oncorhynchus clarki* | n/a | S, U | Tech (90%) | 162 mg/L | 96-h | $LC_{50}$ | 4,880 (4,140-5,730) | Mayer and Ellersieck 1986 |
| Damselfly *Ischura venticalis* | Juv | S, M | Tech (98.7%) | 162-272 as $CaCO_3$ | 96-h | $LC_{50}$ | 33.0 | Mayer and Ellersieck 1986 |
| Fathead minnow *Pimephales promelas* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 8,900 (7,780-10,200) | Mayer and Ellersieck 1986 |
| Fathead minnow *Pimephales promelas* | n/a | S, U | Tech (90%) | 272 mg/L | 96-h | $LC_{50}$ | 9,960 (8,630-11,500) | Mayer and Ellersieck 1986 |
| Fathead minnow *Pimephales promelas* | Larvae | F, M | Tech (80%) | 45.8 mg/L | 96-h | $LC_{50}$ | 5,360 | Jarvinen and Tanner 1982 |

Table A-1. continued-3

| Species | Life Stage | Method* | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.) | Reference |
|---|---|---|---|---|---|---|---|---|
| Goldfish *Caraassius auratus* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 9,000 (8,100-9,900) | Mayer and Ellersieck 1986 |
| Grass shrimp *Palaemonetes vulgaris* | Juv | S, U | Tech (-) | 24 °/∞ | 96-h | $LC_{50}$ | 3.0 | Eisler 1969 |
| Green sunfish *Lepomis cyanellus* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 6,860 (5,590-8,240) | Mayer and Ellersieck 1986 |
| Green sunfish *Lepomis cyanellus* | n/a | S, U | Tech (90%) | 272 mg/L | 96-h | $LC_{50}$ | 6,900 (6,030-7,890) | Mayer and Ellersieck 1986 |
| Hermit crab *Pagurus longicarpus* | Juv | S, U | Tech (-) | 24 °/∞ | 96-h | $LC_{50}$ | 7.0 | Eisler 1969 |
| Lake trout *Salvelinus namaycush* | n/a | S, U | Tech (90%) | 162 mg/L | 96-h | $LC_{50}$ | 3,780 (2,810-5,090) | Mayer and Ellersieck 1986 |
| Lake trout *Salvelinus namaycush* | n/a | S, U | Tech (90%) | 162 mg/L | 96-h | $LC_{50}$ | 3,360 (2,910-3,890) | Mayer and Ellersieck 1986 |
| Largemouth bass *Micropterus salmoides* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 5,220 (4,320-6,310) | Mayer and Ellersieck 1986 |
| Mummichog *Fundulus heteroclitus* | Juv | S, U | Tech (--) | 24 °/∞ | 96-h | $LC_{50}$ | 58,000 | Eisler 1970a |
| Mysid *Neomysis mercedis* | neonate | S, M | Tech (95.7%) | 2 °/∞ 443 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 0.21 (0.17-0.26) | Brandt et al. 1992 |
| Mysid *Neomysis mercedis* | neonate | S, M | Tech (95.7%) | 2 °/∞ 438 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 0.20 (0.17-0.23) | Brandt et al. 1992 |
| Northern puffer *Sphaeroides maculatus* | Juv | S, U | Tech (-) | 24 °/∞ | 96-h | $LC_{50}$ | 75,800 | Eisler 1970a |

Table A-1. continued-4

| Species | Life Stage | Method[a] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.)[c] | Reference |
|---|---|---|---|---|---|---|---|---|
| Rainbow trout *Oncorhynchus mykiss* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 3,700 (3,130-4,380) | Mayer and Ellersieck 1986 |
| Rainbow trout *Oncorhynchus mykiss* | n/a | S, U | Tech (90%) | 272 mg/L | 96-h | $LC_{50}$ | 2,750 (2,000-3,780) | Mayer and Ellersieck 1986 |
| Sand shrimp *Crangon septeopinosa* | Juv | S, U | Tech (-) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | 2.0 | Eisler 1969 |
| Striped bass *Morone saxatilis* | larval | S, M | Tech (95.7%) | 2 °/$_{oo}$ 433 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 4,446 (4,086-5,282) | Fujimura et al. 1991 |
| Striped bass *Morone saxatilis* | larval | S, M | Tech (95.7%) | 2 °/$_{oo}$ 445 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 3,088 (2,822-3,402) | Fujimura et al. 1991 |
| Striped bass *Morone saxatilis* | larval | S, M | Tech (95.7%) | 2 °/$_{oo}$ 416 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 3,400 (2,900-4,000) | Fujimura et al. 1991 |
| Striped killifish *Fundulus majalis* | Juv | S, U | Tech (-) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | 13,800 | Eisler 1970a |
| Striped mullet *Mugil cephalus* | Juv | S, U | Tech (-) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | 5,200 | Eisler 1970a |
| Western chorus frog *Pseudacris triseriata* | Tadpole | S, U | Tech (90%) | 44 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 3,700 | Mayer and Ellersieck 1986 |
| Yellow perch *Perca flarescens* | n/a | S, U | Tech (90%) | 44 mg/L | 96-h | $LC_{50}$ | 3,060 (2,530-3,700) | Mayer and Ellersieck 1986 |

[a] n/a = not available

[b] S = static F = flow through M = measured concentration U = unmeasured concentration

[c] Confidence limits in parentheses.

Table A-2. Values (μg/L) from unaccepted tests on acute toxicity of methyl parathion to aquatic animals.

| Species | Life Stage[a] | Method[b] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.)[c] | Reference | Test Deficiencies[d] |
|---|---|---|---|---|---|---|---|---|---|
| American eel *Anguilla rostrata* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 6,300 | Rehwoldt et al. 1977 | 1 |
| Banded killifish *Fundulus diaphanus* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 15,200 | Rehwoldt et al. 1977 | 1 |
| Bluegill *Lepomis macrochirus* | n/a | S, U | Tech (44.6%) | 51 mg/L $CaCO_3$ | 24-h | $LC_{50}$ | 6,470 | McCann and Jasper 1972 | 1,2 |
| Bluegill *Lepomis macrochirus* | n/a | S, U | ---- | 2-5 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 1,600 | Carter and Graves 1973 | 1 |
| Bluegill *Lepomis macrochirus* | Juv | S, U | Tech (80%) | 20 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 2,400 | Pickering et al. 1962 | 1 |
| Bullfrog *Rana catesbeiana* | Tadpole | S, U | ---- | 2-5 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 6,400 | Carter and Graves 1973 | 1 |
| Carp *Cyprinus carpio* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 14,800 | Rehwoldt et al. 1977 | 1 |
| Catfish *Mystus cavasius* | Juv | F, U | Tech (-) | 123 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 5,900 (5,400-6,500) | Murty et al. 1984 | 1 |
| Channel catfish *Ictalurus punctatus* | Juv | S, U | Tech (80%) | ---- | 96-h | $LC_{50}$ | 5,710 (4,190-7,800) | Macek and McAllister 1970 | 1 |
| Channel catfish *Ictalurus punctatus* | n/a | S, U | ---- | 2-5 mg/L $CaCO_3$ | 24-h | $LC_{50}$ | 9,360 | Carter and Graves 1973 | 1 |
| Cladoceran *Daphnia magna* | 1st instar | S, U | ---- | ---- | 26-h | $LC_{50}$ | 4.8 | Frear and Boyd 1967 | 1,2 |
| Clear Lake gnat *Chaoborus asticopus* | 4th instar | S, U | Tech (80%) | ---- | 24-h | $LC_{50}$ | 5.8 | Hazeltine 1963 | 1,2 |

Table A-2. continued-2

| Species | Life Stage[a] | Method[b] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.)[c] | Reference | Test Deficiencies[d] |
|---|---|---|---|---|---|---|---|---|---|
| Clear Lake gnat *Chaoborus asticopus* | 1st instar | S, U | Tech (80%) | ---- | 24-h | $LC_{50}$ | 1.2 | Hazeltine 1963 | 1,2 |
| Fathead minnow *Pimephales promelas* | n/a | S, U | Tech (80%) | 20 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 10,400 | Henderson and Pickering 1958 | 1 |
| Fathead minnow *Pimephales promelas* | n/a | S, U | Tech (80%) | 400 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 9,400 | Henderson and Pickering 1958 | 1 |
| Fathead minnow *Pimephales promelas* | Juv | S, U | Tech (80%) | 20 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 9,500 | Pickering et al. 1962 | 1 |
| Golden shiner *Notemigonus crysoleucas* | n/a | S, U | Tech (--) | ---- | 48-h | $LC_{50}$ | >5,000 | Minchew and Ferguson 1970 | 1,2 |
| Goldfish *Carassius auratus* | Juv | S, U | Tech (80%) | 20 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 12,000 | Pickering et al. 1962 | 1 |
| Green sunfish *Lepomis cyanellus* | n/a | S, U | Tech (--) | ---- | 48-h | $LC_{50}$ | >5,000 | Minchew and Ferguson 1970 | 1,2 |
| Guppy *Libistes reticulatus* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 6,200 | Rehwoldt et al. 1977 | 1 |
| Guppy *Lebistes reticulatus* | Juv | S, U | Tech (80%) | 20 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 9,800 | Pickering et al. 1962 | 1 |
| Hard-shelled clam *Mercenaria mercenaria* | Adult | S, U | Tech (100%) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | >25,000 | Eisler 1970b | 1 |
| Mosquitofish *Gambusia affinis* | n/a | S, U | ---- | 2-5 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 5,000 | Carter and Graves 1973 | 1 |
| Mosquitofish *Gambusia affinis* | Adult | S, U | Tech (99%) | --- | 48-h | $LC_{50}$ | 13,480 (13,240-13,720) | Chambers and Yarbrough 1974 | 1,2,3,4 |

Table A-2. continued-3

| Species | Life Stage[a] | Method[b] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.)[c] | Reference | Test Deficiencies[d] |
|---|---|---|---|---|---|---|---|---|---|
| Mosquitofish *Gambusia affinis* | Adult | S, U | Tech (99%) | --- | 48-h | $LC_{50}$ | 17,480 (15,670-27,380) | Chambers and Yarbrough 1974 | 1,2,3,4 |
| Mud snail *Nassa obsoleta* | Adult | S, U | Tech (100%) | 24 °/$_{oo}$ | 96-h | $LC_{50}$ | >25,000 | Eisler 1970b | 1 |
| Pumpkinseed *Lepomis gibbosus* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 3,600 | Rehwoldt et al. 1977 | 1 |
| Rainbow trout *Oncorhynchus mykiss* | Juv | S, U | Tech (76.8%) | 272 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 2,800 (2,200-3,500) | Palawski et al. 1983 | 5 |
| Rainbow trout *Oncorhynchus mykiss* | Juv | S, U | Tech (76.8%) | 272 mg/L $CaCO_3$ | 96-h | $EC_{50}$ | 2,000 (1,700-2,300) | Palawski et al. 1983 | 5 |
| Red crawfish *Procambarus clarki* | n/a | S, U | E.C. (51%) | ---- | 36-h | $LC_{50}$ | 41.0 | Chang and Lange 1967 | 1,2,6 |
| Red crawfish *Procambarus clarki* | n/a | S, U | ---- | ---- | 72-h | $LC_{50}$ | 40.0 | Muncy and Oliver 1963 | 1,2 |
| Redear sunfish *Lepomis microlophus* | Juv | S, U | Tech (80%) | ---- | 96-h | $LC_{50}$ | 5,170 (4,410-6,090) | Macek and McAllister 1970 | 1 |
| Siamese fighting fish *Betta splendens* | Adult (male) | S, M | ---- | ---- | 20-h | $LC_{50}$ | <8,000 >7,500 | Welsh and Hanselka 1972 | 1,2 |
| Striped bass *Morone saxatilis* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 14,000 | Rehwoldt et al. 1977 | 1 |
| White perch *Roccus americanus* | Juv | ---- | ---- | 50 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 14,000 | Rehwoldt et al. 1977 | 1 |
| White River crawfish *Procambarus acutus acutus* | n/a | S, U | ---- | 2-5 mg/L $CaCO_3$ | 96-h | $LC_{50}$ | 3.0 | Carter and Graves 1973 | 1 |
| White River crawfish *Procambarus acutus* | n/a | S, U | Tech (--) | 10 mg/L $CaCO_3$ | 48-h | $LC_{50}$ | 2.4 (1.9-3.0) | Albaugh 1972 | 1 |

Table A-2. continued-4

| Species | Life Stage[a] | Method[b] | Formulation | Salinity/ Hardness | Test Length | Effect | Values (95% C.L.)[c] | Reference | Test Deficiencies[d] |
|---|---|---|---|---|---|---|---|---|---|
| White River crawfish *Procambarus acutus* | n/a | S, U | Tech (--) | 10mg/L $CaCO_3$ | 48-h | $LC_{50}$ | 3.4 (3.0-4.0) | Albaugh 1972 | 1 |

[a] n/a = not available

[b] S = static F = flow through M = measured concentration U = unmeasured concentration

[c] Confidence limits in parentheses

[d]
1 = Test lacked essential information
2 = Test duration unacceptable
3 = Test species were captured from wild source
4 = Acclimation of test species insufficient
5 = Insufficient number and range of concentrations tested
6 = Formulation with low % methyl parathion used

APPENDIX B. Abstracts of accepted and unaccepted chronic toxicity tests reviewed for hazard assessment.

***Accepted chronic toxicity tests*** - The following tests used accepted test methods.

Cheminova (1987) - In 1987, a 21-d static toxicity test was conducted on technical methyl parathion (96% active ingredient) with first instar cladoceran *Daphnia magna*. The first part of the study (7-d) was conducted with males and females, measuring mortality response. The second part (remaining 14-d) was performed with females from the first phase of testing, measuring effects on reproduction, mortality, and growth. EPA and FIFRA testing standards were used. Seven concentrations (measured: 12, 24,41,64,121, 166, and 705 ng/L) were replicated 20 times in the first stage and 10 times in the second with a solvent control (one specimen per replication). Water quality parameters during testing were: temperature 20± 1°C, pH 7.98-8.81, dissolved oxygen always greater than 96% of saturation, and hardness 250 ± 25 mg/L as $CaCO_3$. Control survival was 85%. Methyl parathion exposure level measurement found concentrations to be between 90% and 158% of nominal (averaging 93-131%). The NOEC and LOEC values for growth, reproduction, and survival in both stages were 0.166 and 0.705 µg/L, respectively.

Jarvinen and Tanner (1982) - In 1982, a flow-through 32-d embryo-larvae chronic test was performed with technical methyl parathion (80% active ingredient) on embryo fathead minnow *Pimephales promelas*. APHA (1975) bioassay standards were used. Five concentrations (0.31 to 1.55 mg/L) were duplicated and a control was included. Water quality parameters were: temperature of 23.5-26°C, dissolved oxygen of >75%, hardness of 45.8 mg/L as $CaCO_3$, alkalinity of 43.1 mg/L, and pH of 7.4-7.8. Control survival was 100%. Methyl parathion exposure levels were

measured and found to be 97.9 ± 6.4% of nominal. The 32-d NOEC and LOEC values, based on growth, were 0.31 and 0.38 mg/L, respectively.

Norberg-King et al. (1991) - In 1988, a static 7-d chronic toxicity test was conducted with technical methyl-parathion (99.7% active ingredient) on ≤ 4-h old neonate cladoceran *Ceriodaphnia dubia*. EPA (1989) bioassay guidelines were used. Five concentrations were tested and a water control was included. Water quality parameters were: temperature of 25 ± 1°C, dissolved oxygen "adequate", pH of 7.9, and hardness of 45-50 mg/L as $CaCO_3$. Methyl parathion exposure levels were measured. Control survival was 100%. The 7-d NOEC and LOEC values were 0.99 and 1.37 µg/L, respectively.

***Unaccepted chronic toxicity tests*** - The following tests did not use accepted test methods and/or produce accepted results.

Cheminova (1989) - In 1989, a 35-d embryo-to-larvae flow through toxicity test was conducted on technical methyl parathion (95.8% active ingredient) with sheepshead minnows *Cyprinodon variegatus*. Springborn Life Sciences Company testing procedures were used. Five concentrations were duplicated with a solvent and water control. Water quality parameters were: temperature 21-31°C, dissolved oxygen 4.7-6.0 (as low as 53% saturation), pH 7.0 -8.4, and salinity 30-34 $^{o}/_{oo}$. Methyl parathion exposure levels were measured and maintained at 94.6± 8.29% of nominal concentrations. Control survival was 53% (embryos) and 94% (larvae). The 35-d chronic NOEC and LOEC values based on growth (weight) were: 12 µg/L (both stages) and 26 µg/L (both stages), respectively. However, the study noted that the embryo stage tests "did not establish a dose response relationship". These values were not used due to failure to maintain constant temperature, dissolved oxygen levels and embryo survival within the desirable range.

Crossland (1984) - In 1983, a 28-d static renewal toxicity test was conducted on technical methyl parathion (% not given) with juvenile rainbow trout *Oncorhynchus mykiss*. No referenced testing guide was mentioned for this chronic test which measured effect of methyl parathion on growth. Four concentrations were tested with a solvent control. Water quality parameters were: temperature 15-15.5° C, dissolved oxygen 7.7-10.3 mg/L, pH 7.6, and hardness 240-280 mg/L as $CaCO_3$. Methyl parathion exposure level measurements determined concentrations to range from 68-157% of nominal concentrations. Control survival was 100%. The 28-d NOEC and LOEC values based on growth (weight) are 166 and 384 µg/L, respectively. These values were not used because the test was not a true early life-history toxicity test.

Table B-1. Values (µg/L) from accepted tests on the chronic toxicity of methyl parathion to aquatic animals.

| Species | Life Stage | Method[a] | Formulation | Salinity/ Hardness | Test Length | Effect | Values | Reference |
|---|---|---|---|---|---|---|---|---|
| Cladoceran *Ceriodaphnia dubia* | <4-h | S,M | Technical (99.7% a.i.) | 45-50 as $CaCO_3$ | 7-d | NOEC<br>LOEC | 0.99<br>1.37 | Norberg-King et al. 1991 |
| Cladoceran *Daphnia magna* | 1st instar | S, M | Tech (96%) | 250± 25 mg/L $CaCO_3$ | 21-d | NOEC<br>LOEC | 0.17<br>0.70 | Cheminova 1987 |
| Fathead minnow *Pimephales promelas* | embryo-larvae | F,M | Technical (80% a.i.) | 45.8 mg/L as $CaCO_3$ | 32-d | NOEC<br>LOEC | 310<br>380 | Jarvinen and Tanner 1982 |

[a] S = static F = flow through M = measured concentration U = unmeasured concentration

Table B-2. Values (µg/L) unaccepted tests on chronic toxicity of methyl parathion to aquatic animals.

| Species | Life Stage | Method[a] | Formulation | Salinity/ Hardness | Test Length | Effect | Values | Reference | Test Deficiencies[b] |
|---|---|---|---|---|---|---|---|---|---|
| Rainbow trout *Oncorhynchus mykiss* | Juv | S, M | Tech (--) | 240-280 mg/L $CaCO_3$ | 28-d | NOEC<br>LOEC | 166<br>384 | Crossland 1984 | 1 |
| Sheepshead minnow *Cyprinodon variegatus* | embryo-larvae | F, M | Tech (95.8%) | 30-34 °/$_{oo}$ | 35-d | NOEC<br>LOEC | 12<br>26 | Cheminova 1989 | 2,3,4 |

[a] S = static F = flow through M = measured concentration U = unmeasured concentration

[b]
1 = not an early-life stage test
2 = temperature not properly maintained
3 = dissolved oxygen not properly maintained
4 = control survival insufficient

APPENDIX C. Procedures used by the California Department of Fish and Game to assess the hazards of pesticides to the State's aquatic resources.

The California Department of Fish and Game (CDFG) through their Pesticide Investigations Unit (PIU) assesses the hazard of various pesticides on fish and wildlife resources in California. A critical element of CDFG's procedure is the establishment of water quality criteria (WQC) for specific waters of the state using a method modified from guidelines developed by the U.S. Environmental Protection Agency (EPA) (EPA 1985). The CDFG procedure also includes methodology for evaluating the scientific literature so that only data from acceptable toxicity studies are used in generating the WQC. Finally, the hazard assessment procedure is used to determine the effectiveness of the WQC in protecting sensitive aquatic organisms.

The majority of the scientific literature is acquired through departmental and public libraries. In addition, CDFG obtains many corporate laboratory reports through the California Department of Pesticide Regulation (DPR) confidential files which are submitted to EPA in support of pesticide registration. Tests submitted to EPA and DPR must follow stringent pesticide assessment guidelines established by the EPA (1988).

CDFG evaluates the acceptability of toxicity tests reported in the scientific literature by examining the following elements of both acute and chronic tests: 1) test method, 2) test type, 3) test species, 4) water quality maintenance and monitoring, 5) toxicant maintenance, and 6) test design. Within each category are as many as nine elements which are used to evaluate test procedures. While a study need not comply with every element, tests are rejected if they do not observe certain fundamental procedures such as maintaining proper organism survival in control treatments, or testing only with health organisms. Studies are also rejected if they contain insufficient information to properly evaluate toxicity test or if the study does not follow standard testing procedures (ASTM 1980; 1987; 1988a; 1988b).

All acceptable acute and chronic toxicity data from the scientific literature on freshwater and saltwater organisms are used in determining a Final Acute Value, Final Chronic Value and Final Plant Value. The Final Acute Value (FAV) is derived using the following procedure:

1. The Species Mean Acute Value (SMAV) is calculated for each species for which at least one acute value is available as the geometric mean of the results of all acceptable toxicity tests. When one or more life stages are available for the same species, the data for the more sensitive life stages are used in calculating the SMAV. Acute values that

appeared to be questionable [i.e., differ by more than a factor of 10 in comparison with other acute data for the same species and for other species in the same genus] are not used in calculating the SMAV.

2. The Genus Mean Acute Value (GMAV) is calculated for each genus for which one or more SMAVs are available as the geometric mean of the SMAVs available for the genus.

3. The GMAVs are than ranked (R) from "1" for the lowest to "N" for the highest. GMAVs are arbitrarily assigned successive ranks when two or more are identical.

4. The cumulative probability (P) is calculated for each GMAV as R/(N+1).

5. The four GMAVs which had cumulative probabilities closest to 0.05 are selected. When fewer than 59 GMAVs are available, these will always be the four lowest GMAVs).

6. The FAV is calculated using the selected GMAVs and Ps, as follows:

$$S^2 = \frac{\Sigma((\ln GMAV)^2) - ((\Sigma(\ln GMAV))^2/4)}{\Sigma(P) - ((\Sigma(\sqrt{P}))^2/4)}$$

$$L = (\Sigma(\ln GMAV) - S(\Sigma\sqrt{P})))/4$$

$$A = S(\sqrt{0.05}) + L$$

$$FAV = e^A$$

The Final Chronic Value (FCV) is calculated using the same procedure as described for the FAV. When insufficient chronic data are available, the following procedure is used:

1. Chronic values are obtained by calculating the geometric mean of the NOEC and the LOEC from an acceptable chronic toxicity test.

2. Acute-Chronic Ratios (ACR) are calculated for each chronic value for which at least one corresponding appropriate acute value is available using for the numerator the geometric mean of the results of all acceptable acute tests. Whenever possible, the acute test(s) should be part of the same study as the chronic test.

3. The species mean ACR is calculated for each species as the geometric mean of all ACRs available for that species.

4. The Final ACR is calculated as the geometric mean of all the species mean ACRs available for both freshwater and saltwater species.

5. The FCV is then calculated by dividing the FAV by the Final ACR.

When no chronic toxicity data are available, the FCV can be estimated by applying a conversion factor of 0.1 to the lowest acute value.

The Final Plant Value (FPV) is derived using the following procedure:

1. A plant value is the result of a 96-hour test conducted with an algae or a chronic test conducted with an aquatic vascular plant. Because standardized testing procedures have not been established for algae or aquatic vascular plants, all test durations are considered.

2. The FPV is then obtained by selecting the lowest result from a test with an important aquatic plant species in which the endpoint was biologically important.

The WQC is then derived from the lowest of these three values. Separate WQCs can be generated for freshwater and saltwater species if toxicity differences are noted or if the specific water system is strictly saltwater or freshwater (water system does not include an estuary). The WQC can be lowered further to protect important sensitive species.

CDFG performs a hazard assessment by comparing the WQC generated for the specific waters with environmental concentrations. Environmental concentrations are determined through monitoring programs or prediction modeling based on pesticide use information and the physiochemical properties of the substance. If the environmental concentration is greater than the WQC, then CDFG determines that aquatic resources are threatened. A solution to the hazard is then investigated.

The hazard assessment procedure is a reiterative process by which new data are evaluated to refine the WQC. In a hazard assessment document CDFG will usually recommend additional toxicity tests with potentially sensitive native species and commonly used testing organisms listed by ASTM.